Propensity score-matched analysis of oncological outcome between stent as bridge to surgery and emergency resection in patients with malignant left-sided colonic obstruction

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EUROPEAN COLORECTAL CONGRESS

Spotlight on the colon

1 – 5 December 2019, St.Gallen, Switzerland

Sunday, 1 Dec. 2019

MASTERCLASS

09.00
When the appendix plays nasty: intraoperative surprises, immediate solutions, and long-term treatment options
Justin Davies, Cambridge, UK

09.40
All the secrets of the pelvic floor - common disorders and proven solutions
Julie Cornish, Cardiff, UK

10.20
taTME in 2020 – when the dust settles: current and innovative indications, implementation, and practical advices
Roel Hompes, Amsterdam, NL

11.30
Complete mesocolic excision: indications, surgical approaches, and pitfalls
Paris Tekkis, London, UK

12.10
The views of an Editor and the wisdom of an Expert: contemporary publications with the potential to change and improve practice
Neil Mortensen, Oxford, UK

14.00
To ostomize or not and when? The value and downside of a diverting stoma versus virtual ileostomy versus no stoma
Gabriela Möslein, Wuppertal, DE

14.40
Extended lymph node dissection: indications, surgical anatomy, and technical approaches
Peter Sagar, Leeds, UK

15.20
Is the longer the new better - how to safely extend the interval after neoadjuvant chemoradiotherapy prior to surgery for rectal cancer
Ronan O'Connell, Dublin, IE

16:30
The colorectal anastomosis: time-proven wisdom, innovative configurations, and salvage techniques
André d'Hoore, Leuven BE

17.10
All you need to know about stomas but never dared to ask
Willem Bemelman, Amsterdam, NL

17.50
The EBSQ Coloproctology Examination
Michel Adamina, Winterthur, CH

18.00
Wrap-up
Michel Adamina, Winterthur, CH

Monday, 2 Dec. 2019

SCIENTIFIC PROGRAMME

09.45
Opening and welcome
Jochen Lange, St.Gallen, CH

10.00
Pathophysiology and non-operative management of symptomatic uncomplicated diverticular disease
Robin Spiller, Nottingham, UK

10.30
Surgery of acute diverticulitis – evidence, eminence and real life
Willem Bemelman, Amsterdam, NL

11.00
Management of atypical diverticulitis
Dieter Hahnloser, Lausanne, CH

11.30
Hartmann reversal: open, laparoscopic or transanal?
Roel Hompes, Amsterdam, NL

13.30
The surgeon personality – influence on decision making, risk-taking and outcomes
Desmond Winter, Dublin, IE

14.00
SATELLITE SYMPOSIUM
Medtronic

15.00
Clinical applications of image-guided cancer surgery
Cornelis van de Velde, Leiden, NL

16.00
Volvulus of the colon – a treatment algorithm
Peter Sagar, Leeds, UK

16.30
Hereditary colorectal cancer syndromes: tailored surgical treatment
Gabriela Möslein, Wuppertal, DE

17.00
Lars Pahlman and Herand Abcarian (2015)
Herand Abcarian, Chicago, US

17.20
Lars Påhlman Lecture
Steven Wexner, Weston, US

Tuesday, 3 Dec. 2019

09.00
Robotic-assisted versus conventional laparoscopic surgery for rectal cancer
Amjad Parvaiz, Poole, UK

09.30
Robotic multivisceral resection
Paris Tekkis, London, UK

10.00
SATELLITE SYMPOSIUM
Karl Storz

11.30
Neoadjuvant chemotherapy for advanced colon cancer: clinical and pathological Results
Dion Morton, Birmingham, UK
Philip Quirke, Leeds, UK

12.30
Cytoreductive surgery and hyperthermic intraoperative chemotherapy for intestinal and ovarial cancers: lessons learned from 2 decades of clinical trials
Vic Verwaal, Aarhus, DK

14.30
Mechanical bowel obstruction: rush to the OR or stent and dine
Neil Mortensen, Oxford, UK

15.00
Controversies in IBD surgery
André d'Hoore, Leuven, BE

16.00
How to deal with IBD and dysplasia
Janindra Warusavitarne, London, UK

16.30
Perianal Crohn – avoiding delay and best surgical practice
Justin Davies, Cambridge, UK

17.00
Perianal Crohn – stem cells therapy and current medical approach
Gerhard Rogler, Zürich, CH

Wednesday, 4 Dec. 2019

09.00
Is anastomotic leak an infectious disease
Ronan O'Connell, Dublin, IE

09.30
Is it time to invest in robotic surgery?
Antonino Spinelli, Milan, IT

10.00
SATELLITE SYMPOSIUM
Intuitive

11.00
New developments in robotic systems
Alberto Arezzo, Torino, IT

12.00
Posterior component separation for abdominal wall reconstruction: evolution from open to minimal invasive using the robotic platform
Filip Muysoms, Gent, BE

14.00
Coloproctology 4.0 – the networked surgeon
Richard Brady, Newcastle upon Tyne, UK

14.30
SATELLITE SYMPOSIUM
Olympus

15.30
The elderly colorectal patient – functional outcomes and patient reported outcomes
Isacco Montroni, Faenza, IT

16.30
The microbiome and colorectal cancer
Philip Quirke, Leeds, UK

17.00
Surgical management of rectal endometriosis
Eric Rullier, Bordeaux, FR

17.30
EAES Presidential Lecture 3D printing for the general surgeon
Andrea Pietrabissa, Pavia, IT

Thursday, 5 Dec. 2019

09.00
Management of locoregionally advanced colon cancer
Torbjörn Holm, Stockholm, SE

09.30
ROUNDTABLE
Herand Abcarian, Chicago, US
Bill Heald, Basingstoke, UK

10.30
Artificial intelligence in colorectal surgery
Michele Diana, Strasbourg, FR

11.30
The mesentery in colonic diseases
Calvin Coffey, Luimneach, IE

12.00
Technical pearls and typical mistakes in minimal invasive colectomy
Antonio Lacy, Barcelona, ES

12.30
Choosing the right anastomotic technique in colon surgery
Roberto Persiani, Rom, IT

13.00
Precision surgery: past, present and future
Brendan Moran, Basingstoke, UK

13.30
Poster award
Michel Adamina, Winterthur, CH

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Original article

Propensity score-matched analysis of oncological outcome between stent as bridge to surgery and emergency resection in patients with malignant left-sided colonic obstruction

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Background: Although self-expandable metal stent (SEMS) placement as bridge to surgery (BTS) in patients with left-sided obstructing colonic cancer has shown promising short-term results, it is used infrequently owing to uncertainty about its oncological safety. This population study compared long-term oncological outcomes between emergency resection and SEMS placement as BTS.

Methods: Through a national collaborative research project, long-term outcome data were collected for all patients who underwent resection for left-sided obstructing colonic cancer between 2009 and 2016 in 75 Dutch hospitals. Patients were identified from the Dutch Colorectal Audit database. SEMS as BTS was compared with emergency resection in the curative setting after 1 : 2 propensity score matching.

Results: Some 222 patients who had a stent placed were matched to 444 who underwent emergency resection. The overall SEMS-related perforation rate was 7·7 per cent (17 of 222). Three-year locoregional recurrence rates after SEMS insertion and emergency resection were 11·4 and 13·6 per cent ($P = 0·457$), disease-free survival rates were 58·8 and 52·6 per cent ($P = 0·175$), and overall survival rates were 74·0 and 68·3 per cent ($P = 0·231$), respectively. SEMS placement resulted in significantly fewer permanent stomas (23·9 *versus* 45·3 per cent; $P < 0·001$), especially in elderly patients (29·0 *versus* 57·9 per cent; $P < 0·001$). For patients in the SEMS group with or without perforation, 3-year locoregional recurrence rates were 18 and 11·0 per cent ($P = 0·432$), disease-free survival rates were 49 and 59·6 per cent ($P = 0·717$), and overall survival rates 61 and 75·1 per cent ($P = 0·529$), respectively.

Conclusion: Overall, SEMS as BTS seems an oncologically safe alternative to emergency resection with fewer permanent stomas. Nevertheless, the risk of SEMS-related perforation, as well as permanent stoma, might influence shared decision-making for individual patients.

*Members of the Dutch Snapshot Research Group are co-authors of this study and can be found under the heading Collaborators

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Introduction

Of all patients with colonic cancer, 9–13 per cent present initially with an acute obstruction, which accounts for 85 per cent of colonic emergencies[1,2]. Traditionally, left-sided obstructing colonic cancer (LSOCC) has been managed with emergency resection[3]. However, as patients presenting with LSOCC are often elderly and frequently in poor clinical condition, emergency resection has been associated with substantial morbidity and mortality rates[1,3–5]. In addition, many patients end up with a permanent stoma, which is known to have a negative impact on quality of life and independence[6,7].

In the past decade, self-expandable metal stent (SEMS) placement has been proposed as an alternative to emergency resection for LSOCC. Initial decompression

of the distended colon by SEMS placement can transform the resection into an elective procedure, enabling a laparoscopic approach in a clinically optimized patient. Meta-analyses[8,9] have confirmed higher proportions of laparoscopic surgery after SEMS placement, with lower postoperative morbidity rates, fewer temporary stomas and higher primary anastomosis rates.

Even though the short-term benefit has been established in recent years, SEMS as bridge to surgery (BTS) for curative treatment of LSOCC is currently not recommended as a standard treatment in international guidelines[10]. Concerns include a higher rate of perineural invasion and an increase in tumour cell dissemination after stent insertion[11–14]. Furthermore, stent- or guidewire-related perforations may increase the risk of recurrence[15]. SEMS as BTS has been associated with worse survival[16], although this has not been confirmed by recent meta-analyses[17–19].

Treatment of LSOCC in the Netherlands has been influenced strongly by two multicentre Dutch randomized trials, Stent-In 1 and 2[20,21]. After early termination of both trials because of increased morbidity in the experimental arms, SEMS has been used infrequently, with only a few centres continuing to perform stenting. Although the use of stent placement increased following publication of the European Society of Gastrointestinal Endoscopy (ESGE) guidelines[10] in 2014, where stenting as BTS is recommended in elderly patients with a high operative risk (ASA fitness grade III–IV), emergency resection is still the preferred approach in the vast majority of Dutch hospitals. Allocation of treatment in the Netherlands is therefore mainly hospital-based instead of patient-based. The aim of this propensity score-matched population-based analysis was to provide real-world evidence[22] on the long-term oncological outcomes after SEMS as BTS and emergency resection for LSOCC.

Methods

A retrospective national collaborative research project was conducted in the Netherlands. The methodology was described in the first publication of the Dutch Snapshot Research Group (DSRG)[23]. Briefly, short-term data from all patients in the Netherlands undergoing resection of primary colorectal cancer are collected prospectively in the Dutch Colorectal Audit (DCRA, formerly known as DSCA). It is mandatory for all Dutch hospitals to register their patients in the DCRA. All patients who underwent resection for LSOCC between 2009 and 2016 were identified from the DCRA database. Short-term DCRA data were extended with additional procedural data, and long-term surgical and oncological data. For collection of these additional data, a web-based tool was developed and controlled in accordance with privacy regulations by Medical Research Data Management (Deventer, the Netherlands).

All 77 Dutch hospitals were invited to participate in this project. Collaborators in each participating hospital were asked to provide data on their registered patients. Under the supervision of one or two consultants, surgical residents performed web-based data collection between August 2017 and December 2017. These data were then analysed for discrepancies and missing values. Any discrepancies were communicated back to the participants, who were asked to verify or complete the data. All local investigators had an extra month for data correction. After the period of data verification, the final data extraction was carried out in January 2018. The combined set of DCRA and DSRG data was anonymized and was sent to the central research coordinator. The study was designed and manuscript prepared in accordance with the STROBE statement[24]. The medical ethics committee of the Academic Medical Centre in Amsterdam reviewed and approved the observational study design, and decided that informed consent did not need to be obtained as there was no additional burden for the patient owing to the observational design of the study.

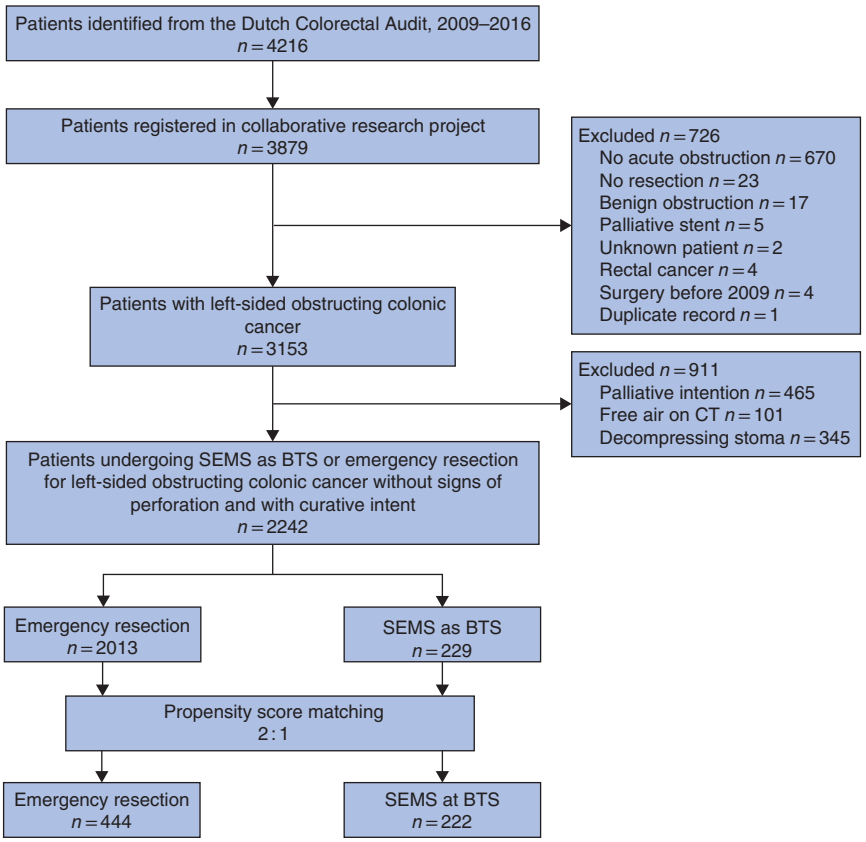
Patient selection

Patients treated for LSOCC in 2009–2016 were selected from the DCRA database using primary tumour location (splenic flexure, descending colon or sigmoid) and either registration of clinical obstruction and/or an intervention (SEMS placement) preceding primary tumour resection. Patients who presented with perforation and those who had preoperative radiotherapy were excluded.

The DSRG collaborators then reviewed all original patient files individually based on eligibility criteria, with additional variables on signs of clinical obstruction taken into consideration to allow more precise patient selection. Patients were considered to have acute colonic obstruction when they had at least one clinical sign of colonic obstruction (bloated abdomen, nausea and/or vomiting) and radiological signs of colonic obstruction on CT (dilated large and/or small bowel loop).

For this analysis, only data on patients who underwent either SEMS as BTS or emergency resection with curative intent were extracted. Whether a patient was treated with curative intent was one of the variables acquired in the DSRG data set. Centres performing SEMS placement were categorized for subgroup analysis; high-volume centres were defined as those in which over 70 per cent of

Fig. 1 Flow chart showing patient selection



SEMS, self-expandable metal stent; BTS, bridge to surgery.

patients with LSOCC were treated with SEMS and stents were placed by an experienced endoscopist (at least 20 procedures).

Endpoints

The primary endpoints were 3-year disease-free and overall survival. Secondary outcomes were locoregional recurrence and permanent stoma rates. Locoregional recurrence was defined as a recurrence at the level of the anastomosis, in a locoregional lymph node or a peritoneal metastasis.

Adjuvant chemotherapy and follow-up

The Dutch colorectal cancer guidelines[25] recommend adjuvant chemotherapy in patients with high-risk stage II (T4, fewer than 10 lymph nodes harvested, presentation with obstruction, vascular invasion, undifferentiated tumour) and stage III disease. Adjuvant chemotherapy until 2016 consisted of either FOLFOX (oxalipatin, leucovorin, 5-fluorouracil) or CAPOX (capecitabine, oxaliplatin) for a total of 6 months.

Follow-up according to the guidelines[25] included clinical visits at 6-month intervals for the first 2–3 years and yearly thereafter until 5 years after curative resection, with at least carcinoembryonic antigen (CEA) measurement at each visit. Abdominal (liver) ultrasonography or CT was recommended every 6 months for 1–2 years after resection and yearly thereafter. In addition, surveillance colonoscopy was performed at 1 and 4 years after resection.

Statistical analysis

As patients were not assigned randomly to a treatment approach, a propensity score method was used to balance baseline co-variables between groups. Co-variables were selected *a priori*, and included age, sex, ASA grade, BMI, pathological T, N and M categories, tumour location, year of presentation, tumour length on CT and previous abdominal surgery. Before calculating the propensity

Table 1 Baseline characteristics before and after propensity score matching

	Before PS matching			After PS matching		
	Emergency resection ($n = 2013$)	SEMS as BTS ($n = 229$)	MSD (%)	Emergency resection ($n = 444$)	SEMS as BTS ($n = 222$)	MSD (%)
Age (years)*	71 (62–79)	72 (64–80)	6·8	73 (63–79)	72 (64–80)	1·7
Sex ratio (M : F)	1071 : 942	128 : 101	5·4	253 : 191	124 : 98	2·3
BMI (kg/m^2)†	25·5(4·2)	25·7(4·3)	8·3	24·7(4·2)	24·9(4·4)	2·5
ASA fitness grade						
I	355 (17·7)	49 (21·7)	10·0	94 (21·4)	48 (21·8)	0·5
II	968 (48·2)	120 (53·1)	9·5	227 (51·6)	117 (53·2)	4·5
III	593 (29·5)	53 (23·5)	14·9	110 (25·0)	51 (23·2)	4·8
IV	91 (4·5)	4 (1·8)	21·1	9 (2·0)	4 (1·8)	1·7
Missing	6	3		4	2	
pT category						
pT1–2	78 (3·9)	12 (5·3)	2·1	26 (5·9)	11 (5·0)	3·8
pT3	1399 (69·7)	162 (72·0)	4·6	313 (70·7)	158 (71·8)	2·5
pT4	530 (26·4)	51 (22·7)	9·7	104 (23·5)	51 (23·2)	1·1
Missing	6	4		1	2	
pN category						
pN0	928 (46·4)	111 (49·3)	4·1	220 (49·8)	105 (47·9)	3·8
pN1	699 (34·9)	73 (32·4)	6·5	140 (31·7)	73 (33·3)	2·3
pN2	374 (18·7)	41 (18·2)	0·4	82 (18·6)	41 (18·7)	1·1
Missing	12	4		2	3	
Metastases present at presentation	186 (9·2)	24 (10·5)	4·2	50 (11·3)	22 (10·0)	4·5
Previous abdominal surgery	595 (29·6)	53 (23·1)	14·4	112 (25·2)	53 (23·9)	2·9
Tumour location						
Sigmoid	1364 (67·8)	169 (73·8)	7·2	322 (72·5)	162 (73·0)	1·0
Descending colon	375 (18·6)	45 (19·7)	2·5	91 (20·5)	45 (20·3)	0·5
Splenic flexure	274 (13·6)	15 (6·6)	13·7	31 (7·0)	15 (6·8)	0·8
Median length of stenosis (cm)*	4 (3–6)	4 (3–5)	23·6	4 (3–5)	4 (3–5)	6·5

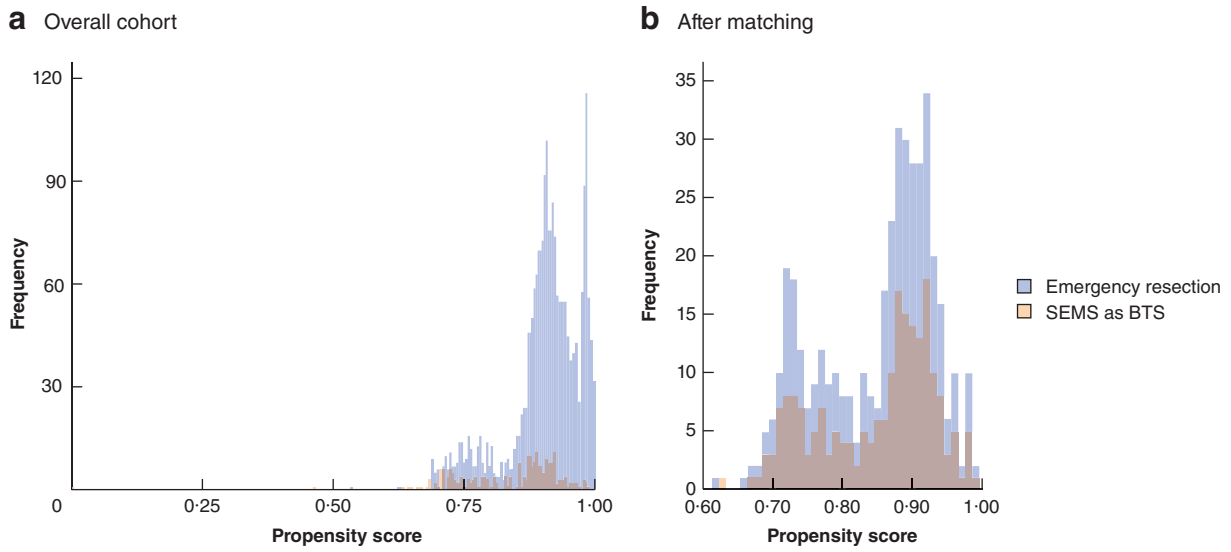
Values in parentheses are percentages unless indicated otherwise; *values are median (i.q.r.) and †mean(s.d.). PS, propensity score; SEMS, self-expandable metallic stent; BTS, bridge to surgery; MSD, mean standardized difference.

score, missing data were imputed using multiple imputation by chained equations. One-to-two nearest neighbour matching without replacement (optimal matching) was performed within a calliper of 0·2 logit of the standard deviation of the propensity score[26]. The propensity score was then evaluated using Nagelkerke's R^2 statistic as a measure of fit, with a score close to 0 indicating good overlap in the treatment groups. The co-variable balance of the matched cohort was assessed using mean standardized differences, with differences of less than 10 per cent indicating good balance.

Categorical or dichotomous variables are presented as absolute numbers with percentages, and were compared before matching using the χ^2 test. After matching, in order to account for the matched nature of data, outcome variables were assessed by means of conditional logistic regression[27,28]. Continuous variables are shown as mean(s.d.) or median (i.q.r.) according to their distribution. Depending on the distribution, treatment groups were compared using independent Student's *t* test or Mann–Whitney *U* test before matching; paired *t* test was used after matching. All analyses were conducted based on the intention-to-treat principle (emergency resection for SEMS perforation was analysed in the SEMS group).

Comparison of survival probabilities in the matched cohort was performed using a Cox proportional hazards model with shared frailty. To verify the results in the matched groups, survival analyses were also carried out for the entire patient cohort before matching, with propensity score as a correcting factor. Subgroup analyses were undertaken to compare outcome parameters in the SEMS group for patients with SEMS-related perforation *versus* no perforation, and treatment at high- *versus* low-volume centres. Survival curves in the SEMS group were plotted according to the Kaplan–Meier method and tested for significant

Fig. 2 Overlap in propensity score between treatment groups before and after matching



a Overall cohort and **b** after matching. SEMS, self-expandable metal stent; BTS, bridge to surgery. Nagelkerke $R^2 = 0{\cdot}095$ in overall cohort.

Table 2 Treatment characteristics in the matched cohort

	Emergency resection ($n = 444$)	SEMS as BTS ($n = 222$)	Hazard ratio‡#	*P***
Surgical approach				<0·001
Open	410 (93·0)	126 (57·5)		
Laparoscopic	31 (7·0)	93 (42·5)	9·27 (5·58,15·39)	
Missing	3	3		
Resection type			0·94 (0·83, 1·08)	0·391
Sigmoid resection	279 (62·8)	132 (59·5)		
Left hemicolectomy	99 (22·3)	68 (30·6)		
Subtotal colectomy	28 (6·3)	6 (2·7)		
Anterior resection	11 (2·5)	7 (3·2)		
Other	27 (6·1)	9 (4·1)		
Primary anastomosis	177 (39·9)	165 (74·3)	4·18 (2·87, 6·08)	<0·001
Temporary stoma	290 (65·3)	63 (28·4)	0·20 (0·14, 0·30)	<0·001
Age < 70 years	116 of 183 (63·4)	21 of 91 (23)	0·14 (0·06, 0·36)	<0·001
Age ≥ 70 years	174 of 261 (66·7)	42 of 131 (32·1)	0·18 (0·09, 0·34)	<0·001
No. of lymph nodes resected*	14 (10–19)	16 (13–23)	1·03 (1·01, 1·05)	<0·001
No. of patients with a complication				
During the entire treatment approach§	186 (41·9)	95 (42·8)	0·96 (0·68, 1·37)	0·831
Anastomotic leakage¶	25 of 177 (14·1)	18 of 165 (10·9)	0·65 (0·30, 1·42)	0·279
Complications requiring reintervention	35 (7·9)	24 (10·8)	1·43 (0·81, 2·54)	0·223
Following tumour resection	186 (41·9)	78 (35·1)	0·77 (0·55, 1·08)	0·095
90-day or in-hospital mortality	28 (6·3)	12 (5·4)	0·85 (0·43, 1·70)	0·647
Adjuvant chemotherapy	165 (37·2)	84 (37·8)	0·97 (0·70, 1·35)	0·868
Time to start of adjuvant chemotherapy after resection (weeks)*	6 (5–9)	9 (7–12)	1·04 (0·99, 1·08)	0·113

Values in parentheses are percentages unless indicated otherwise; *values are median (i.q.r.) and ‡values in parentheses are 95 per cent confidence intervals. §Complications after self-expandable metal stent (SEMS) placement and/or tumour resection combined. ¶For patients who had a primary anastomosis. #Emergency surgery is the reference group. **Conditional logistic regression analysis.

Table 3 Long-term outcomes in the matched cohort

	Emergency resection ($n = 444$)	SEMS as BTS ($n = 222$)	Hazard ratio‡§	P¶
Median follow-up (months)*	34 (15–58)	42 (17–65)	1·01 (1·00, 1·02)	0·002
Permanent stoma at end of follow-up	201 (45·3)	53 (23·9)	0·39 (0·28, 0·57)	< 0·001
Age < 70 years	50 of 183 (27·3)	15 of 91 (16)	0·53 (0·23, 1·24)	0·014
Age ≥ 70 years	151 of 261 (57·9)	38 of 131 (29·0)	0·36 (0·21, 0·62)	< 0·001
Any recurrence during follow-up	225 (50·7)	105 (47·3)	0·90 (0·64, 1·26)	0·541
Locoregional recurrence	53 (11·9)	22 (9·9)	0·88 (0·50, 1·54)	0·655
Anastomotic recurrence	15 (28)	7 (32)		
Loco-regional lymph node metastasis	1 (2)	2 (9)		
Peritoneal metastasis	37 (70)	13 (59)		
Distant metastases	118 (26·6)	48 (21·6)	0·75 (0·50, 1·14)	0·125
Para-aortic lymph node metastasis	3 (2·5)	2 (4·1)		
Liver	73 (61·9)	32 (67)		
Lung	59 (50·0)	19 (40)		
Bone	5 (4·2)	4 (8)		
Brain	6 (5·1)	3 (6)		
Actuarial 3-year rates (%)#				
Locoregional recurrence	13·6	11·4	0·84 (0·72, 1·96)	0·457
Disease-free survival	52·6	58·8	0·83 (0·92, 1·57)	0·175
Overall survival	68·3	74·0	0·85 (0·90, 1·53)	0·231

Values in parentheses are percentages unless indicated otherwise; *values are median (i.q.r.) and ‡values in parentheses are 95 per cent confidence intervals. §Emergency resection is reference group. SEMS, self-expandable metal stent; BTS, bridge to surgery. ¶Conditional logistic regression analysis, except #determined by Kaplan–Meier analysis and tested using Cox proportional hazards model with shared frailty.

differences using the log rank test. Two-sided $P < 0·050$ was considered significant. All analyses were performed with SPSS® version 25.0 (IBM, Armonk, New York, USA) and R version R3.3.2 (Matching and Frailtypack package, MICE package; R Foundation for Statistical Computing, Vienna, Austria).

Results

Seventy-five of 77 Dutch hospitals participated in this collaborative research project. A total of 3879 patients were registered of the 4216 patients identified (92·0 per cent) (*Fig. 1*). After retrospective evaluation of original patient files, 726 patients were excluded, of whom 670 appeared to be registered incorrectly in the DCRA as having an obstruction (stricturing tumour, unable to pass with the endoscope, but without clinical signs of obstruction). This resulted in an overall cohort of 3153 patients with LSOCC. Applying eligibility criteria for the present analysis resulted in 2242 patients, of whom 229 underwent SEMS as BTS and 2013 emergency resection. Using 1 : 2 propensity score matching, 222 patients in the SEMS group were matched to 444 in the emergency resection group. Seven patients in the SEMS group were excluded as no matches could be found in the emergency resection group.

Before matching, baseline characteristics were biased for ASA grade, previous abdominal surgery, tumour location and tumour length on CT (mean standardized difference over 10 per cent) (*Table 1*). After propensity score matching, none of these differences remained. Histograms of the estimated propensity scores before and after matching are shown in *Fig. 2*. The Nagelkerke's R^2 value of 0·095 indicates a good overlap in propensity scores between treatment groups. The degree of overlay in propensity score (*Fig. 2b*), and standardized mean differences between baseline variables below 10 per cent for all variables, indicated that matching was successful in obtaining two well balanced groups.

There were no missing data in the unmatched data set for age, sex, primary tumour location, year of presentation, anastomotic leakage, 90-day mortality and overall survival. Data for all other baseline and outcome variables in the matched data set were missing for less than 3 per cent of patients, except for local recurrence during follow-up, which was missing for 34 of 666 patients (5·1 per cent), and metastasis during follow-up, which was missing for 26 of 666 patients (3·9 per cent). Missing values for variables used to calculate the propensity score were completed by multiple imputation (ASA grade, previous abdominal surgery, TNM categories, BMI and tumour length on CT).

Treatment characteristics

The overall technical success rate of SEMS was 87·4 per cent (194 of 222 patients). The two main reasons for technical failure were not being able to pass the guidewire (14) or SEMS (4) past the obstruction. Owing to technical SEMS failure, 22 patients had to undergo emergency resection within 24 h, three patients had a decompressing stoma constructed, and a second attempt at SEMS placement was successful in the remaining three patients.

Two guidewire perforations and six clinically overt SEMS-related perforations occurred, and all these patients underwent emergency resection. During the elective resection, two silent SEMS perforations were noted. In addition, the pathologist reported microperforation by a SEMS in seven other patients. The overall perforation rate was 7·7 per cent (17 of 222).

Of all SEMS procedures, 129 (58·1 per cent) were performed in five of 75 participating hospitals. Two hospitals were considered high volume and 85 of the 222 SEMS were carried out in these two institutions. Technical success rates in high- and low-volume SEMS centres were 78 of 85 (92 per cent) and 116 of 137 (84·7 per cent) respectively ($P = 0·207$). Corresponding clinical success rates were 71 of 85 (84 per cent) and 106 of 137 (77·4 per cent) ($P = 0·483$). The rate of SEMS-related complications (6 of 85 (7 per cent) *versus* 18 of 137 (13·1 per cent); $P = 0·184$) and SEMS-related perforations (4 of 85 (5 per cent) *versus* 13 of 137 (9·5 per cent); $P = 0·299$) was lower in high-volume centres, but the differences were not significant.

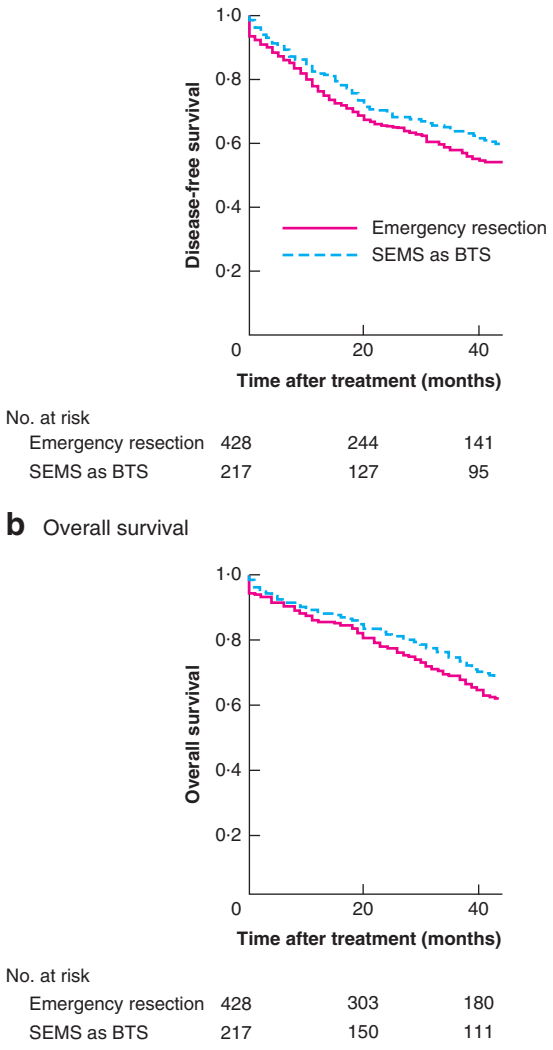
Table 2 summarizes treatment characteristics of the emergency resection and SEMS groups. Patients in the SEMS group more often underwent laparoscopic resection (42·5 *versus* 7·0 per cent; hazard ratio (HR) 9·27, 95 per cent c.i. 5·58 to 15·39; $P < 0·001$), more often had a primary anastomosis (74·3 *versus* 39·9 per cent; HR 4·18, 2·87 to 6·08; $P < 0·001$) and were less likely to have a temporary stoma (28·4 *versus* 65·3 per cent; HR 0·20, 0·14 to 0·30; $P < 0·001$). Thirty- and 90-day mortality rates, morbidity rate and the proportion of patients who underwent adjuvant chemotherapy did not differ between treatment groups.

Long-term outcomes

Median follow-up in the emergency resection and SEMS groups was 34 (i.q.r. 15–58) and 42 (17–65) months respectively. Overall long-term outcomes are summarized in *Table 3*. Three-year disease-free survival rates were 52·6 and 58·8 per cent for emergency resection and SEMS groups respectively (HR 0·83, 95 per cent c.i. 0·92 to 1·57; $P = 0·175$) (*Fig. 3*). Three-year overall survival rates were 68·3 and 74·0 per cent respectively (HR 0·85, 0·90 to 1·53; $P = 0·231$). Additional Cox regression analysis of the unmatched data set (2242 patients) similarly showed no significant difference between treatment groups in disease-free survival (HR 0·91, 0·61 to 3·76) or overall survival (HR 0·94, 0·64 to 5·21).

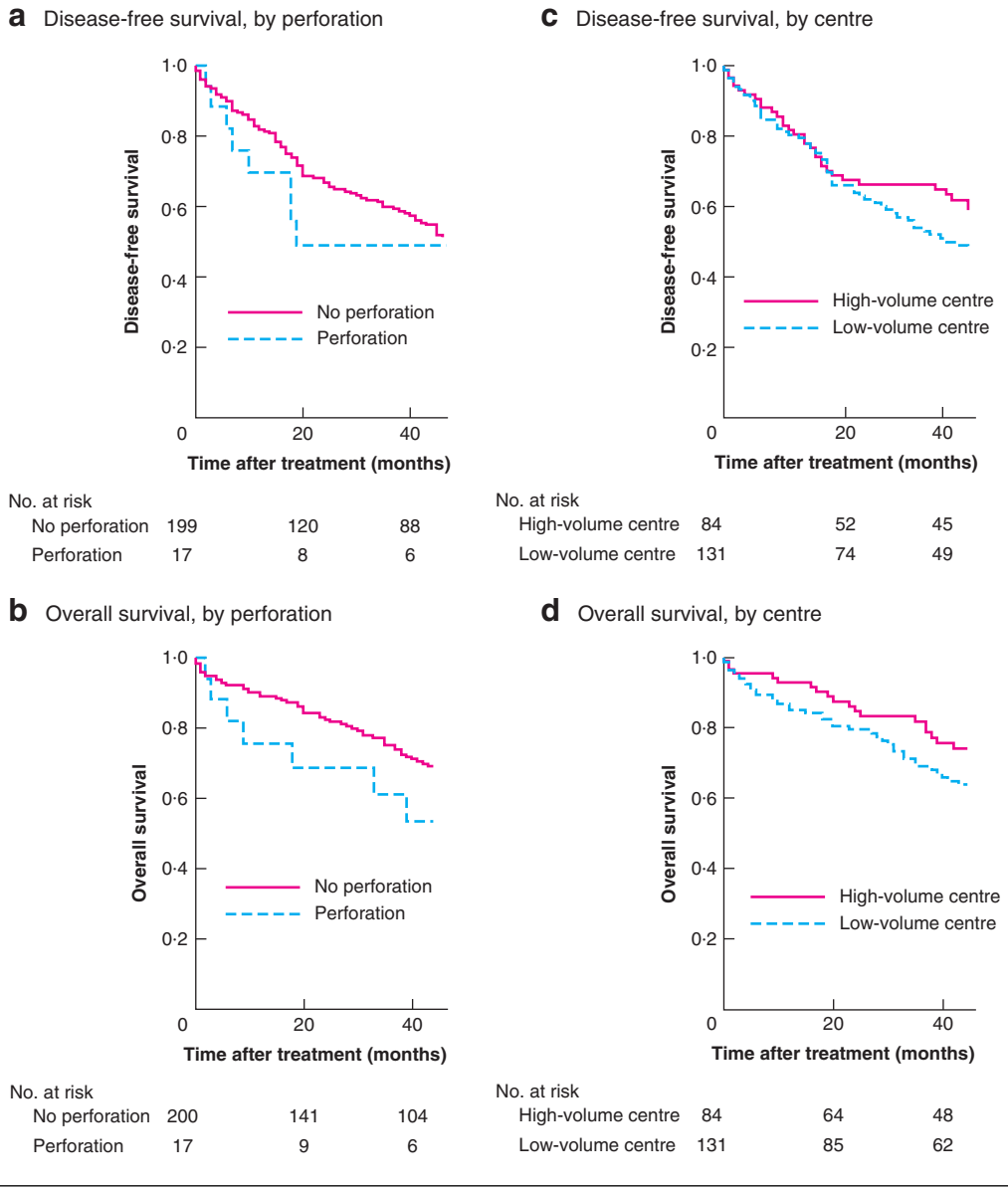
Three-year locoregional recurrence rates were 13·6 and 11·4 per cent in the emergency resection and SEMS groups

Fig. 3 Kaplan–Meier curves comparing disease-free and overall survival after emergency resection *versus* self-expandable metal stent placement as bridge to surgery



a Disease-free survival and **b** overall survival. SEMS, self-expandable metal stent; BTS, bridge to surgery. **a** $P = 0·175$, **b** $P = 0·231$ (frailty analysis).

Fig. 4 Survival after self-expandable metal stent placement as bridge to surgery in relation to perforation and type of treatment centre



a Disease-free and **b** overall survival in patients with or without perforation; **c** disease-free and **d** overall survival in patients treated in high- or low-volume centres. **a** $P = 0{\cdot}717$, **b** $P = 0{\cdot}529$, **c** $P = 0{\cdot}169$, **d** $P = 0{\cdot}103$ (log rank test).

respectively (HR 0·84, 0·72 to 1·96; $P = 0{\cdot}457$). Patients in the emergency resection group were almost twice as likely to have a permanent stoma at the end of follow-up than those in the SEMS group (45·3 *versus* 23·9 per cent; HR 0·40, 0·28 to 0·57; $P < 0{\cdot}001$). Younger patients (aged less than 70 years) were significantly more likely to have a temporary stoma reversed than elderly patients: 73 of 137 (53·3 per cent) *versus* 30 of 216 (13·9 per cent ($P < 0{\cdot}001$). Whether the stoma was reversed was independent of the treatment approach.

Comparing oncological outcomes after SEMS as BTS with or without guidewire- or SEMS-related perforation, 3-year disease-free survival rates were 49 and 59·6 per cent ($P = 0{\cdot}717$), and 3-year overall survival rates 61 and 75·1 per cent ($P = 0{\cdot}529$), respectively (*Fig. 4a,b*). Three-year locoregional recurrence rates in patients with and without

perforation were 18 and 11·0 per cent ($P = 0·432$). Comparing patients treated at high- and low-volume SEMS centres revealed 3-year disease-free survival rates of 66 *versus* 55·7 per cent ($P = 0·169$), 3-year overall survival rates of 82 *versus* 68·9 per cent ($P = 0·103$) and 3-year locoregional recurrence rates of 12 *versus* 11·2 per cent ($P = 0·975$).

Discussion

In this study, SEMS placement as BTS with curative intent in patients presenting with LSOCC was not associated with impaired long-term oncological outcomes. Compared with emergency resection, no significant differences in locoregional recurrence, disease-free and overall survival rates were found. The SEMS-related perforation rate was 7·7 per cent, with worse oncological outcomes in this small subgroup, although they were not significantly different from those in patients who underwent stent placement without perforation. High-volume SEMS centres had better results, but not significantly different from those of low-volume centres. Patients in the SEMS group had significantly fewer permanent stomas at the end of follow-up, especially elderly patients.

Although the short-term benefits of SEMS placement have been well established, concerns have been raised about worse oncological outcomes[14,16]. In particular, SEMS-related perforations have been associated with an increase in locoregional recurrence and possible worse survival in the past[15,29–31]. The present results are consistent with this, as the 17 patients who suffered a SEMS-related perforation had a higher recurrence rate and worse survival, although there was insufficient statistical power for firm conclusions to be drawn.

Concerns about oncological outcomes have also been raised in the event of uncomplicated SEMS placement. Several studies[11–16] have reported on pathophysiological mechanisms that could possibly lead to worse oncological outcome after SEMS insertion. These concerns are reflected in the current ESGE guideline[10], which states that SEMS placement should be first choice only in palliative situations or in patients with an increased surgical risk (aged at least 70 years and/or ASA grade III or more) and in centres with substantial experience.

Since publication of the ESGE guideline, multiple studies, including recent meta-analyses, have investigated long-term outcomes following SEMS placement compared with emergency resection[17,19]. They were not able to demonstrate a significant survival difference between treatment groups. Unfortunately, most studies were retrospective and underpowered, they seldom had recurrence and survival as the primary outcome measures, and follow-up was often relatively short. Only a recent study by Kang and co-workers[32], which compared 226 patients who had SEMS placement with 109 who underwent emergency resection using propensity score as a co-variable, focused specifically on long-term outcomes. Although matching in this cohort was not possible owing to lack of control patients and insufficient overlap of propensity scores between treatment groups, the methodology is stronger than that of previous studies. They also reported no significant difference in (locoregional) recurrence and survival rates[32]. The results of the present analysis of a propensity score-matched cohort, including 666 patients of whom 222 were treated with a SEMS, further strengthens the previously published conclusions regarding the oncological safety of stenting in LSOCC.

Overall, the 7·7 per cent perforation rate and its impact on survival did not seem to influence the oncological outcome in the complete SEMS group, as recurrence and survival rates were similar in both treatment groups. Worse survival owing to perforation might therefore be counterbalanced by a positive impact of stenting in other SEMS subgroups. For instance, several studies have shown that postoperative complications (which tended to occur more frequently in the emergency resection group in the present study) also have a negative effect on oncological outcome[33]. Therefore, different risks and potential advantages related to both strategies should be considered when deciding on optimal management for the individual patient. For example, a young fit patient with a low operative risk profile and absence of competing mortality risks (cardiovascular) might not want to take the risk of perforation during stent insertion. On the other hand, the risk of perforation might be outweighed by the high operative risk in elderly patients or those with significant co-morbidity. The difference in risk of permanent stoma between age groups should also be taken into account, underlining the need for patient-tailored treatment and shared decision-making in patients with LSOCC.

Given its oncological impact, it is crucial to minimize perforation risk. Experience of the endoscopist seems important[34]. The present results support this, as subanalysis of high- *versus* low-volume SEMS centres showed a lower perforation rate in the high-volume centres, where SEMS placement is undertaken only by experienced endoscopists.

An important strength of the present study is the high participation rate (92·0 per cent of identified patients were registered). In total, 75 of the 77 centres contributed to this national cohort study, resulting in good representation of current nationwide practice. In addition, small pretreatment differences suggested a low risk of selection bias,

probably related to the fact that treatment choices were mostly according to institutional protocol, rather than selective allocation to a certain intervention. Furthermore, detailed retrospective review of the original patient files enabled validation and enrichment of the DCRA data set. Finally, the robustness of the findings is supported by the fact that two different analytical methods resulted in similar outcomes.

Nonetheless, several limitations should be kept in mind. Only patients who underwent colonic resection are included in the DCRA registry. Thus, patients who died as a consequence of SEMS placement remained beyond the scope of the present study. However, as no postoperative deaths after SEMS placement have been reported in any RCT reporting on SEMS as BTS, the influence of this shortcoming is expected to be negligible[8]. In addition, defining acute colonic obstruction is difficult in the absence of international consensus, and using retrospective chart review. Inherent to real-world evidence, the authors were not informed about the degree of adherence to guidelines regarding follow-up, although there is strong evidence that differences in intensity of follow-up after colorectal cancer treatment do not influence survival[35]. No specific data on the surgeons who performed the (emergency) resections were available owing to the retrospective nature of the study. Finally, although propensity score matching was used to minimize selection bias, there might still be residual confounding due to unknown factors.

Overall, the data from this propensity score-matched population study indicate that SEMS as BTS is not negatively associated with long-term oncological outcomes and has a lower risk of permanent stoma than emergency resection. Therefore, SEMS placement appears to be a valid and safe alternative in dedicated centres. Nevertheless, the risk of SEMS-related perforation, as well as permanent stoma risk, might influence shared decision-making in individual patients with LSOCC.

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